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THE MICROSCOPIC IDENTIFICATION OF COMMERCIAL FUR HAIRS

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(From the Zoological Laboratory, Cornell University)

THE use of the furry pelts of animals as articles of clothing is of very ancient origin, and probably contemporaneous with the beginnings of the manufacture of flint artifacts and war clubs. Its use as a decoration for the body, began presumably, somewhat later. The oriental peoples, as early as 2000 B.C. were using furs, not only as a protection against cold, but also as articles of luxury, and Herodotus mentions their use by other ancient peoples. Furs were much prized by the Romans, particularly during the later days of the empire, and the Saracens also made extensive use of them. It was from this latter source that the Crusaders first introduced furs into Europe, where they met with immediate favor, particularly among the nobles and clergy, where they were used in ceremonial regalia. The popularity of furs early rose to such a pitch that, in England and France, sumptuary edicts were issued against their unrestricted use, which did little, however, to check the increasing demand. It was to meet this demand that those hardy pioneers and explorers, the trappers and fur traders, penetrated far into the wildernesses of the then unknown northern portions of North America, and established there the trading stations which later came to play such important rôles in the spread of the white man in America.

The use of furs as necessary articles of clothing as well as for ornamental purposes, is as great to-day as ever, and indeed during the past several years seems to have increased the severity of its demands. Certain mammals are being rapidly reduced in numbers, if not threatened with extinction; and certain furs are becoming rare and consequently expensive. Hence there arises the necessity for some methods whereby the species from which any given fur was obtained can be indubitably determined. For it is possible to remodel and rename furs, that is, so to clip, dye and pull them, that their original appearance is altered to such an extent that they may be sold under names not their own. Furs so remodelled may be sold

under the names of furs much superior in wearing quality or in warmth.

Thus the pelts of animals from warmer zones such as the woodchuck (marmot), opossum, Australian opossum, raccoon, weasel, Tartar pony, Manchurian dog, and certain monkeys are worked up by fur dressers into articles but little resembling their originals and sold under other names, usually under the names of animals of northern latitudes. Such furs are inferior to those from colder climates in suppleness and durability of leather, denseness and silkiness of under, or fur-hair, fullness of over- or protective hair, and because dyed, brittle and less durable in general. One of the most durable of all furs is that of the sea otter (*Latax lutris*). Considering this to be represented by 100, the relative durability of some common furs, when used with the fur outside (not for linings), is as follows:¹

Species	Durability (Otter = 100)
1. Beaver	90
2. Bear, black or brown	94
3. Chinchilla	15
4. Ermine	25
5. Fox, natural	40
6. Fox, dyed	20-25
7. Goat	15
8. Hare	05
9. Kolinsky	25
10. Leopard	75
11. Lynx	25
12. Marten (skunk)	70
13. Mink, natural	70
14. Mink, dyed	35
15. Mole	07
16. Muskrat	45
17. Nutria (Coypu rat), plucked	25
18. Otter, sea	100
19. Otter, inland	100
20. Opossum	37
21. Rabbit	05
22. Raccoon, natural	65
23. Raccoon, dyed	50
24. Sable	60
25. Seal, hair	80
26. Seal, fur	80
27. Squirrel, gray	20-25
28. Wolf	50
29. Wolverine	100

¹ Modified, from Peterson, "The Fur Trade and Fur Bearing Animals," Buffalo, 1914.

The misnaming of furs offered for sale in England reached, several years ago, such magnitude that the London Chamber of Commerce gave notice that misleading names were not to be employed, and that offenders were liable to prosecution. More definite legislation than now exists ought also to be had in this country. The following table² lists some of the best known furs, and their usual misnomers.

Species	Altered and Sold as
1. American sable	Russian sable
2. Fitch, dyed	Sable
3. Goat, dyed	Bear, of various kinds
4. Hare, dyed	Sable or fox
5. Kid	Lamb
6. Woodchuck (marmot), dyed	Mink, sable, skunk
7. Mink, dyed	Sable
8. Muskrat (musquash), dyed	Mink, sable
9. Muskrat (musquash), pulled and dyed.....	Seal, electric seal, Hudson Bay Seal, Red River seal
10. Nutria (Coypu rat), pulled and dyed.....	Seal, electric seal, Hudson Bay seal, Red River seal
11. Nutria (Coypu rat), pulled, naturall.....	Beaver, otter
12. Opossum, sheared and dyed	Beaver
13. Otter, pulled and dyed	Seal of various kinds
14. Rabbit, dyed	Sable
15. Rabbit, sheared and dyed	Seal, electric seal, Hudson Bay seal, Red River seal, musquash
16. Rabbit, white	Ermine
17. Rabbit, white, dyed	Chinchilla
18. Kangaroo (wallaby), various species, dyed...	Skunk (marten)
19. Hare, white	Fox
20. Goat, dyed	Leopard

Up to the present time no very dependable series of criteria for the indubitable identification of mammal hairs was to be had. In a recent paper on the microscopic structure of mammalian hair³ the author has pointed out that the constant characteristics of certain microscopic elements in the structure of the hair shaft are significant from several zoological viewpoints. That the results of the application of these criteria for the identification of commercial fur hairs may be of practical value

² Modified, from Jones, "Fur Farming in Canada" (Canada Commission of Conservation), Ottawa, 1914.

³ Hausman, L. A., "A Micrological Investigation of the Definitive Hair Structure of the Mammalia, with Especial Reference to the Monotremata" (in press).

to the general public as well, it is the object of this paper to point out.

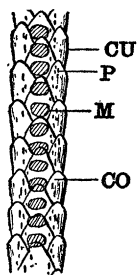
In order to appreciate the nature of the microscopic elements of the hair structure used in identification, it will be helpful to pass briefly in review the structure of the typical mammalian hair. Hairs arise from the bases of relatively deep pits in the epidermis, or outer layer of the skin, known as follicles, and push upward, being added to from the base, in a rod-like growth, of circular or elliptical cross section, and are composed of four elements (Fig. 1): (1) the *medulla* (*M*), or pith, consisting of many superimposed cells or chambers, which may be either separate or massed, (2) the *cortex* (*CO*), or shell, surrounding the medulla, of tough, horny, homogeneous texture and hyaline appearance, (3) the *pigment granules* (*P*), to which the color of the hair is primarily due, scattered about within the corticular substance, and (4) the *cuticle* (*CU*), or outermost integument of the hair shaft, lying upon the cortex and composed of plate-like scales, imbricated somewhat like the shingles on a roof. It is the form and interrelationships of these various structural elements, together with the diameter of the hair shaft, which form the series of determinative criteria to which reference has been made.

Medullas occur in four distinct forms: (1) the *discontinuous medulla*, as in the hair of the duck bill, or platypus, Fig. 27; (2) the *continuous medulla*, as in the hair of the red fox, Fig. 8; (3) the *interrupted medulla*, as in the hair of the hair seal, Fig. 13, which is a type intermediate between the first two; and (4) the *fragmental medulla*, as in the hair of the European otter, Fig. 11. It will be noted, furthermore, that the hair of some species lacks the medulla altogether.

The cortex, since it is usually of homogeneous structure, shows few or no compositional characteristics, and when used in description is merely measured as to thickness between the cuticle and medulla.

The pigment granules when present, are usually of characteristic form and distribution, and can often be used for one of the criteria for identification.

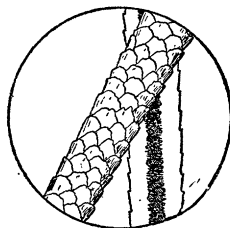
The elements, however, which presents the most readily usable and definite characteristics, are the scales of the cuticle. They fall into two great formal groups: (1) the *imbricate interrupted* type, those which lie singly imbricated about the hair shaft, like shingles on a roof, as in the hair of the Coypu rat, Fig. 18; and (2) the *imbricate coronal* type, those which



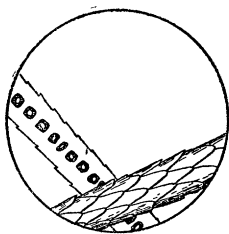
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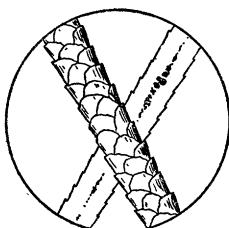
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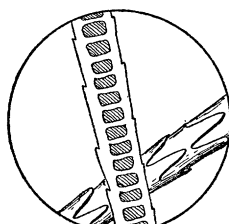
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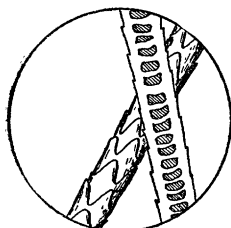
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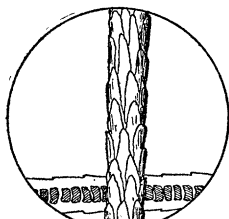
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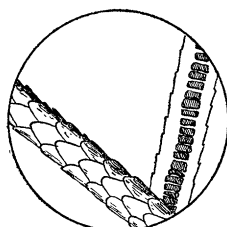
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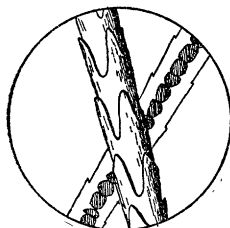
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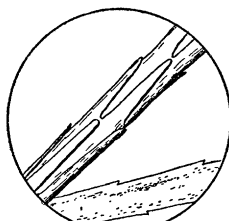
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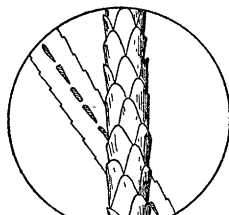
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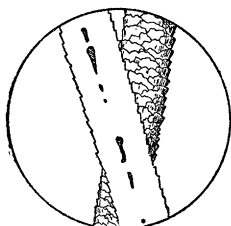
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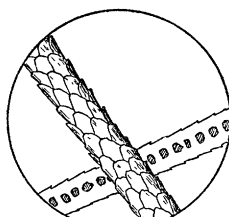
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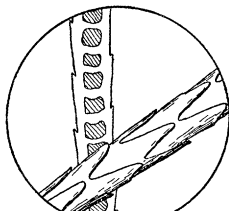
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encircle the hair shaft as continuous bands, as in the hair of the ermine, Fig. 6. Of these two types there are a multitude of intricate variations.

The hair covering of most mammals consists of two kinds of hair; a soft, thick, under hair, called the *fur hair*, and a longer, stouter hair, which overlies the fur hair, termed the *protective hair*. In commerce the names under hair and over hair are usually employed. Microscopic examination of the structures used for identification may be made, as is sometimes necessary, of both these kinds of hair. It is usually sufficient, however, to subject only the fur hair to examination.

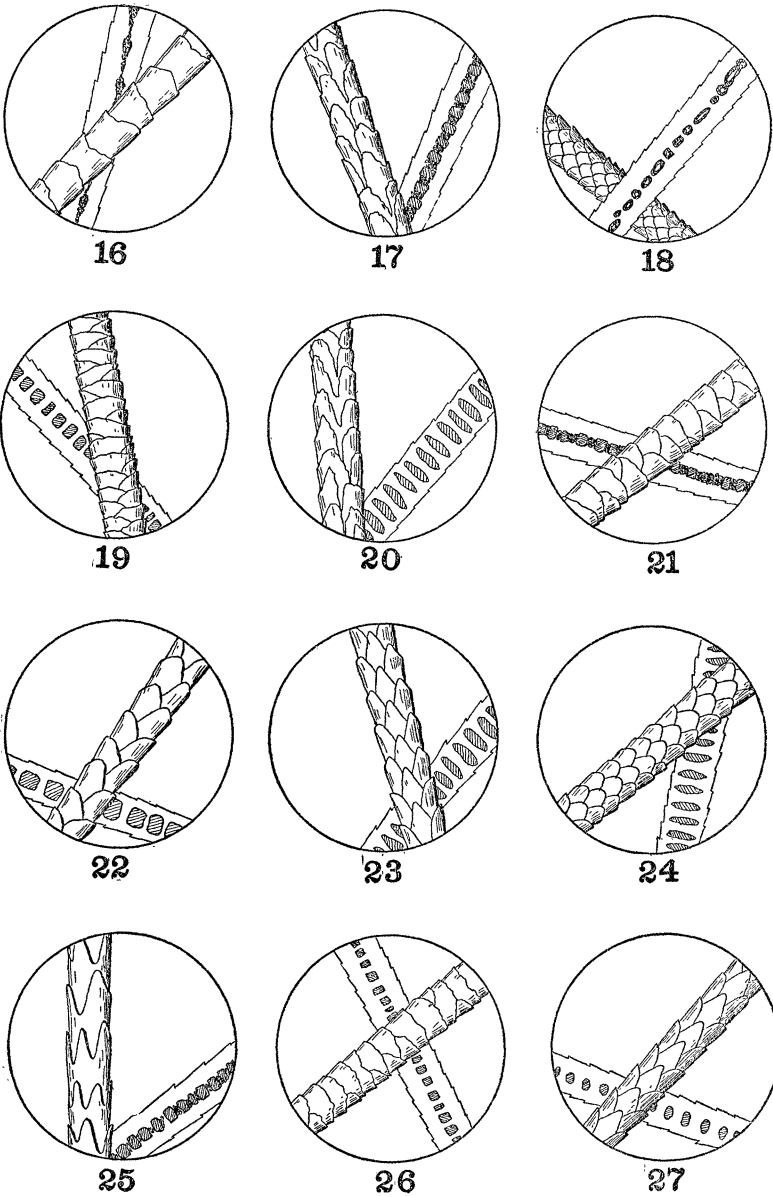
The preparation of hair for ordinary examination is not laborious. Several hair shafts are taken, and washed in a solution composed of equal parts of 95 per cent. alcohol and ether, to remove any oily matter from their surfaces. They are then transferred to a clean glass slide; covered with a cover glass, and allowed to stand in a current of warm air until thoroughly dry. Examination can now be made directly, using the 8x ocular and the 16 mm. and 4 mm. objectives. This simple treat-

FIG. 1. IDEAL GENERALIZED MAMMAL HAIR, TO SHOW THE STRUCTURE. CU, cuticle; CO, cortex; M, medulla; P, pigment granules.

FIG. 2. TRANSVERSE SECTION THROUGH TWO HAIR SHAFTS FROM THE DUCK BILL, OR *Platypus*. CU, cuticle; CO, cortex; M, medulla; P, pigment granules.

ORDER FERÆ (THE CARNIVORA)

- FIG. 3. Badger (*Taxidea americana*), 57.
 FIG. 4. Black bear (*Ursinus americanus*), various varieties of, 27.
 European brown bear (*Ursus arctos*).
 FIG. 5. Civet (*Arctogalidia fusca*), 21.
 Domestic cat (*Felis catus*).
 Wild cat (several species).
 FIG. 6. Ermine (*Putorius erminea*), 17.
 FIG. 7. Fitch (*Mustela putorius*), 18.
 FIG. 8. Red fox (*Vulpes pennsylvanicus*), with its various varieties, 19.
 Genet (*Viverra genetta*).
 Kolinsky (see Siberian mink).
 Leopard (*Felis pardus*).
 FIG. 9. Canada lynx (*Lynx canadensis*), 19.
 Marten (see skunk).
 Pine marten (*Mustela martes*).
 Stone marten (*Mustela foina*).
 FIG. 10. Mink (*Putorius vison*), with its various varieties, 11.
 Siberian mink (*Mustela sibirica*).
 American otter (*Lutra canadensis*).
 FIG. 11. European otter (*Lutra vulgaris*), 10.
 Sea otter (*Lutra lutris*).
 FIG. 12. Raccoon (*Procyon lotor*), 20.
 American sable (*Mustela americana*).
 Russian sable (*Mustela zibellina*).
 Fur seal (*Callorhinus ursinus*), and other species.
 FIG. 13. Hair seal (*Otaria jubata*), 105. Sea lions of the genera *Eumetopias*, and *Zalophus* are also used.
 FIG. 14. Skunk (*Mephitis mephitis*), 26.
 FIG. 15. Wolverine (*Gulo luscus*), 25.



ORDER GLIRES (THE RODENTS)

- FIG. 16. American beaver (*Castor canadensis*), 18.
 European beaver (*Castor fiber*).
 FIG. 17. Chinchilla (*Chinchilla lanigera*), 16.
 FIG. 18. Coypu rat, or nutria (*Myocastor coypus*), 11.
 Cony (see rabbit).
 Hare (*Lepus americanus virginianus*) and other species.
 Marmot (see woodchuck).
 Nutria (see Coypu rat).

ment answers very well for those hairs whose structural elements are large and prominent, such as those of the European otter, Fig. 11, and of the American beaver, Fig. 16. In other cases the hairs must be washed in the ether-alcohol as before, and then dipped with forceps into a 95 per cent. alcoholic solution of gentian violet, methyl blue, methyl violet, Bismarck brown, or safranin, of a degree of color depth which must be empirically determined for the best results with each different species of hair. This treatment renders clear the outlines of the individual scales. However, even this manipulation fails to reveal the contour of the scales of certain hairs, and various other methods devised by the writer, too lengthy for description here, must be called into service. Treatment with caustics, such as caustic soda or potash; or with acids, such as nitric or hydrochloric, which have sometimes been recommended, distorts the scales and thereby renders them valueless for delicate determinative purposes.

The treatments used to render the cuticular scales visible, obscure the medulla, hence other methods are necessary to bring into prominence this element of the hair structure. The simplest and most generally useful of these is to mount the hair on a slide in some one of the light oils used in micrological work, such as oil of cloves, oil of bergamont, oil of cedar, etc., after having washed the hair, as before, in the ether-alcohol solution. With some few hairs it is satisfactory to use clear water as the mounting medium. The methods used to bring the medulla into

FIG. 19. American gray squirrel (*Sciurus carolinensis*), 18.

Siberian gray squirrel (*Sciurus vulgaris*).

FIG. 20. Rabbit (*Lepus nutalli malurus*), and other species, 17.

FIG. 21. Woodchuck (*Arctomys monax*), 22.

FIG. 22. Muskrat (*Fiber zibethicus*), 17.

ORDER UNGULATA (THE HOOFED MAMMALS)

Domestic goat (*Capra hircus*).

Pony, or domestic horse.

Astrachan (*Ovis aries*), and its varieties.

ORDER INSECTIVORA (THE MOLES, SHREWS, ETC.)

FIG. 23. European mole (*Talpa europea*), 17.

FIG. 24. American mole (*Scalops aquaticus*), 17.

ORDER MARSUPIALIA (THE POUCHED MAMMALS)

FIG. 25. Koala (*Phascolarctos cinereus*), 22.

FIG. 26. Opossum (*Didelphys virginiana*), 37.

Rock wallaby (*Petrogala pencillata*).

Yellow wallaby (*Petrogale xanthopus*).

ORDER MONOTREMATA (THE EGG-LAYING MAMMALS)

FIG. 27. Duck bill, or platypus (*Ornithorhynchus anatinus*), 8.

clear visibility are also useful for rendering plain the pigment granules.

For the measurements of the diameter of the hair shaft, the ocular micrometer is perhaps the most satisfactory. Since, in any given tuft of hairs, there is considerable variation in the diameters of the individual shafts, the average of many measurements should be taken.

It was sometimes, though fortunately not frequently, found necessary to prepare transverse sections of the hair shafts, to determine more fully the contour of the medulla. Fig. 2 shows two shafts of the fur hair of the duck bill, or platypus, sectioned in this way.

In the following classified list are enumerated those mammals whose pelages are the most extensively used in the fur trade. The numbers against some of these, which are the most common, are the numbers of the figures wherein is shown the microscopic appearance of the fur hair. In each figure two hair shafts are depicted, one treated to show the cuticular scales; the other to show the medulla. The hair shafts are not drawn to scale; where there is so great variation in diameters this is not practicable. Hence, following the name of each species whose hair is figured, appears the average diameter of the shafts of the fur hairs, expressed in micra.⁴

⁴ One micron 1/1,000 of a millimeter, or circa 1/254,000 inch.